CLAIMS

1. A fluid sensor for use in an environment having an ambient temperature, the fluid sensor comprising:

a) a field-effect transistor (FET) comprising a functionalized semiconductor nano-wire,

b) an integral heater disposed proximate to the field-effect transistor to heat the field-effect transistor to an elevated temperature relative to the ambient temperature, and

c) integral thermal insulation disposed to maintain the field-effect transistor at the elevated temperature.

2. The fluid sensor of claim 1, wherein the functionalized semiconductor nano-wire comprises silicon.

3. The fluid sensor of claim 2, wherein the silicon of the functionalized semiconductor nano-wire is doped to provide a predetermined conductivity type.

4. The fluid sensor of claim 1, wherein the functionalized semiconductor nano-wire comprises a catalyst.

5. The fluid sensor of claim 4, wherein the catalyst comprises a material capable of interacting with a fluid to be sensed and effecting a change of an electrical characteristic of the field-effect transistor (FET).

6. The fluid sensor of claim 4, wherein the catalyst comprises a metallic catalyst.

7. The fluid sensor of claim 4, wherein the catalyst is a material selected from the list consisting of platinum, palladium, iridium, rhenium, ruthenium, gold, silver, and mixtures or alloys or compounds thereof; carbon; tungsten, titanium, tin, zinc, and oxides thereof; organometallic compounds containing elements from the group consisting of cobalt, iron, and nickel; and transition metal complexes containing elements from Groups IIIA, IVA, VA, VIA, VIIA, VIIIA, IB, IIB of the Periodic Table of Elements.

8. The fluid sensor of claim 4, wherein the catalyst comprises a porous thin layer of catalyst material.

9. The fluid sensor of claim 8, wherein pores of the porous thin layer of catalyst material extend at least partially through the thin layer of catalyst material.

10. The fluid sensor of claim 4, wherein the catalyst comprises a mesh formed by thin filaments of catalyst material.

11. The fluid sensor of claim 1, wherein the functionalized semiconductor nano-wire comprises a silicon nano-wire functionalized with a material capable of interacting with a fluid to be sensed and effecting a change of an electrical characteristic of the field-effect transistor (FET).

12. The fluid sensor of claim 1, wherein the functionalized semiconductor nano-wire comprises a silicon nano-wire functionalized with a catalyst selected from the list consisting of: platinum, palladium, iridium, rhenium, ruthenium, gold, silver, and mixtures or alloys or compounds thereof; carbon; tungsten, titanium, tin, zinc, and oxides thereof; carbon; tungsten, titanium and oxides thereof; organometallic compounds containing elements from the group consisting of cobalt, iron, and nickel; and transition metal complexes containing elements

from Groups IIIA, IVA, VA, VIA, VIIA, VIIIA, IB, IIB of the Periodic Table of Elements.

13. The fluid sensor of claim 1, further comprising a substrate for supporting the field-effect transistor.

14. The fluid sensor of claim 13, wherein the field-effect transistor and the substrate are formed from a layer of silicon on an insulator (SOI).

15. The fluid sensor of claim 14, wherein the field-effect transistor and the substrate are formed from a layer of silicon on an insulator layer comprising silicon oxide.

16. The fluid sensor of claim 13, wherein the integral thermal insulation is disposed on the substrate.

17. The fluid sensor of claim 13, wherein the integral heater is disposed on the substrate.

18. The fluid sensor of claim 13, wherein the integral heater is disposed on the integral thermal insulation.

19. The fluid sensor of claim 13, wherein the field-effect transistor (FET) is disposed on the substrate.

20. The fluid sensor of claim 13, wherein the field-effect transistor (FET) is disposed on the integral thermal insulation.

21. The fluid sensor of claim 13, wherein a portion of the substrate is removed to form an opening under the field-effect transistor (FET), the opening being at least partially aligned with the field-effect transistor.

22. The fluid sensor of claim 13, wherein the substrate serves as a gate for the field-effect transistor.

23. The fluid sensor of claim 13, wherein the field-effect transistor includes a gate electrically insulated from the substrate.

24. The fluid sensor of claim 13, wherein the functionalized semiconductor nano-wire comprises a conductive catalyst electrically insulated from the substrate to provide a gate for the field-effect transistor.

25. The fluid sensor of claim 1, further comprising at least one integral temperature sensor disposed proximate to the field-effect transistor for determining the temperature thereof.

26. A fluid-sensor array, each fluid sensor of the fluid-sensor array comprising the fluid sensor of claim 25.

27. A fluid-sensor array, each fluid sensor of the fluid-sensor array comprising the fluid sensor of claim 1.

28. The fluid-sensor array of claim 27, further comprising at least one integral temperature sensor for determining a temperature thereof.

29. The fluid-sensor array of claim 27, wherein the field-effect transistor of each fluid sensor of the array is functionalized for detecting a particular substance.

30. The fluid-sensor array of claim 27, wherein the field-effect transistor of each fluid sensor of the array is functionalized for detecting a distinct substance.

31. The fluid-sensor array of claim 27, wherein the field-effect transistors of a number of the fluid sensors of the array are functionalized for detecting the same substance.

32. The fluid-sensor array of claim 27, further comprising at least one field-effect transistor not functionalized for detecting a substance, whereby at least one control device is provided.

33. A fluid sensor for use in an environment having an ambient temperature, the fluid sensor comprising:

a) functionalized nano-scale field-effect-transistor means for detecting a fluid,

b) integral means for heating the means for detecting a fluid,

d) integral means for thermally insulating at least the means for detecting a fluid, and

e) means for supporting the means for detecting a fluid, the integral means for heating, and the integral means for thermally insulating.

34. The fluid sensor of claim 33, wherein the integral means for heating comprises means for heating the means for detecting a fluid to an elevated temperature relative to the ambient temperature, and the integral means for thermally insulating comprises means for maintaining the means for detecting a fluid at the elevated temperature.

35. The fluid sensor of claim 33, further comprising integral means for determining the temperature of the means for detecting a fluid.

36. The fluid sensor of claim 33, wherein the means for detecting a fluid comprises means for detecting a gas.

37. A method for fabricating a fluid sensor, the method comprising the steps of:

a) providing an insulating substrate,

b) depositing a layer of silicon on the insulating substrate to form a silicon-on-insulator (SOI) substrate,

c) patterning the layer of silicon to form at least one silicon nano-wire and at least one integral heater resistor,

d) forming conductive source and drain contacts, thereby combining the source and drain contacts with the semiconductor nano-wire to form a field-effect transistor,

e) functionalizing the at least one silicon nano-wire for detection of at least one gas, and

f) depositing thermal insulation disposed to maintain the field-effect transistor at an elevated temperature relative to the ambient temperature of the fluid sensor.

38. The method of claim 37, wherein the silicon-layer patterning step c) is performed by nanolithography.

39. The method of claim 37, wherein the silicon-layer patterning step c) is performed using a lithography method selected from the list consisting of nano-imprint lithography, electron-beam lithography, ion-beam lithography, deep-UV lithography, and X-ray lithography.

40. The method of claim 37, wherein the step d) of forming conductive source and drain contacts is performed by nanolithography.

41. The method of claim 37, wherein the step d) of forming conductive source and drain contacts is performed using a lithography method selected from the list consisting of nano-imprint lithography, electron-beam lithography, ion-beam lithography, deep-UV lithography, and X-ray lithography.

42. The method of claim 37, wherein the step of functionalizing the at least one silicon nano-wire comprises depositing a quantity of a material capable of interacting with a fluid to be sensed and effecting a change of an electrical characteristic of the field-effect transistor (FET).

43. The method of claim 37, wherein the step of functionalizing the at least one silicon nano-wire comprises depositing a quantity of catalyst on the silicon nano-wire.

44. The method of claim 37, wherein the step of functionalizing the at least one silicon nano-wire comprises depositing on the silicon nano-wire a quantity of a catalyst selected from the list consisting of: platinum, palladium, iridium, rhenium, ruthenium, gold, silver, and mixtures or alloys or compounds thereof; carbon; tungsten, titanium, tin, zinc, and oxides thereof; organometallic compounds containing elements from the group consisting of cobalt, iron, and nickel; and transition metal complexes containing elements from Groups IIIA, IVA, VA, VIA, VIIA, VIIIA, IB, IIB of the Periodic Table of Elements.

45. The method of claim 37, wherein the step of functionalizing the at least one silicon nano-wire includes forming a gate for the field-effect transistor (FET).

46. The method of claim 37, further comprising the step of removing at least a portion of the substrate under the field-effect transistor (FET).

47. The method of claim 46, wherein the step of removing at least a portion of the substrate is performed by etching the back side of the substrate to form an opening at least partially aligned with the field-effect transistor (FET).

48. The method of claim 37, further comprising the steps of patterning the semiconductor film and forming a junction to make a diode with known temperature-dependent electrical characteristics, whereby an integral temperature sensor is formed.

49. A fluid sensor fabricated by the method of claim 48.

50. A method of using the fluid sensor of claim 49, comprising the steps of:

a) associating with each of two or more fluids to be sensed a different operating temperature range effective for sensing the fluid to be sensed,

b) sensing a temperature of the fluid sensor by operating the integral temperature sensor, and

c) actuating the integral heater to adjust the temperature of the fluid sensor to within a selected operating temperature range, whereby one of the two or more fluids to be sensed is selected for sensing.

51. A fluid sensor fabricated by the method of claim 37.

52. An integrated circuit comprising the fluid sensor of claim 51.

53. A fluid-sensor array, each fluid sensor of the fluid-sensor array being fabricated by the method of claim 37.

54. An integrated circuit comprising the fluid-sensor array of claim 53.

55. A method of using a fluid sensor having an integral heater and an integral temperature sensor, the method comprising the steps of:

a) associating with each of two or more fluids to be sensed a different operating temperature range effective for sensing the fluid to be sensed,

b) sensing a temperature of the fluid sensor by operating the integral temperature sensor, and

c) actuating the integral heater to adjust the temperature of the fluid sensor to within a selected operating temperature range, whereby one of the two or more fluids to be sensed is selected for sensing.